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ABSTRACT

The authors argue against the current view of task analysis which assumes that learning is a univariant process. They feel that learning is a multivariant process and that task analysis should also take into consideration an analysis of the learning task, the cognitive processes which affect the acquisition of the learning task, and the learner's personality variables which may interact with the task and/or process of acquisition. Task analysis techniques must go beyond the formal-procedural (training) domain into what is termed a "thematic-principle" domain. They propose three procedures for such an analysis: specification of an appropriate cognitive process, an analysis of task structure, and an analysis of the contribution of aptitude measures on task performance. To demonstrate the feasibility of such an analytical procedure, a developmental research project is described which involved the manipulation of several sequence variables. (JY)

BEYOND THE REMEDIAL LOOP: TOWARD THE INTEGRATION OF TASK AND LEARNER ANALYSIS FOR A PROCESS APPROACH TO INSTRUCTIONAL DEVELOPMENT[1]

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Introduction

The methodological and theoretical issues to be discussed in this paper have been selected in an attempt to argue for increased sophistication in present task analysis techniques--a sophistication that would not only result in the univariant analysis of task structure but in the multivariant analysis of related cognitive process and personalogical variables as well. Such integration has been suggested for research in the past; most notably by Cronbach (1957), Melton (1964, 1967), and Jensen (1967); and might be characterized by a shift in our theoretical base from S-R theory to S-R association and information processing theory.

Task analysis, as currently defined in the literature, seems to operate on the assumption that learning is a univariant process. A representative task analysis bibliography would include topics from the use of logic trees in teaching armed services accounting procedures (Hickey, 1964) to a complex analysis of a hierarchical learning task in some science or mathematics content area (Gagne, 1970; Merrill, 1965). The basic assumption that seems to operate is that: <u>All individual differences can be equalized by a</u>

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thorough and empirically determined task structure which is used in the determination of a well designed and, subsequently, validated learning sequence. A learner, typically, proceeds step-by-step to criterion. If a stage in the learning is not achieved, the learner goes back through the loop (or branches) until mastery is achieved. It is a remediation model, with time as the equalizer of individual differences.

We are arguing for the position that learning is a multivariant process and that "task analysis" should include an analysis of the learning task, the cognitive processes which affect the acquisition of the learning task and the personalogical variables which may interact with the task and/or process of acquisition. The basic assumption operating here is: Effective and efficient learning will, ultimately, be achieved by analysis in the aforementioned areas and instructional sequences and strategies which are validated on different subpopulations of individuals. A more complex mediational model is suggested where a learner may proceed through quite different treatments which affect different psychological functions (mediators) augmenting the same mental processes (and subsequent R's) for different kinds of learners.

Using the notion of "learning to learn" defined by Harlow (although perhaps with greater liberty than he would advise); the learner, when confronted with a novel task, must learn to learn by countering his own past history with those tasks set before him. He brings his own strategies and ways of viewing the world to bear on the task. In the univariant remediation model, the uniqueness of the learner is not taken into account. It is observed only in time to criterion and previous learning, both of which vary across individuals to the extent that individuals must remediate.

But as we begin to look at multivariant process variables, we can account for time to criterion variance in terms of differential cognitive processes by preference or compensation (Snow, 1970), interacting personalogical variables and, of course, the more conventional notion of previous learning.

What are the benefits to be derived? Once we begin to look at the interaction of process and task, both inter- and intra-individually, our analyses of tasks will accommodate individual differences among sub-populations of learners by providing a theoretical base for differentiated prescription of treatments and, in addition, give us a start on the most perplexing problem of deriving instructional treatments directly from our analyses. We doubt that few developers would disagree with the proposition that design of strategies or treatments is largely an intuitive process. At best, treatments are perfected after several trial-revision cycles. Through validation we are probably "strong arming" individual differences much to our clients' detriment. The link between our theoretical analysis and full specification of strategies seems to be at an advanced stage of folk art.

Time to criterion as our dependent variable can theoretically be augmented by acquisition of multiple mediating responses in the individual learner as he achieves criterion. New directions in task analysis should thus specify not only the required tasks but also the nature of the mediating processes at each stage of acquisition for specified sub-populations. Such inquiry might well proceed in the manners suggested by Melton (1967), Salomon (1971) and Glanzer (1967). With respect to implicit methodological concern for inter- and intra-task measurement, Snow (1966) has provided us an excellent introduction to the case for the multivariate examination of response complexity in the learner during acquisition. Anderson (1967) speaks of the need for factor analytic techniques for the purpose of revealing patterns in which skills load on tasks, and their relative importance. The backward learning curves of Zeamen and House (1967) offer an interesting technique. And Alvord (1969) demonstrates the use of intra-task measures in a study of individual differences in concept attainment and transfer. The Cronbach and Snow (1969) monograph is surely one of the most useful resources at hand for refining a methodology and taking us toward our goal, as is Bracht's (1969,1970) review and comments on aptitude treatment interaction research.

On the other hand, however, you might well question the pragmatism of the multivariant process approach recommended here when basic research is just beginning to shed light on and bring improvements in the analysis of learning tasks from the univariant point of view (Resnick, 1969).

Our rationale can be summarized by three basic propositions, partially advanced above. I. Recent research rather clearly demonstrates that learning in several kinds of tasks is a multivariant phenomena. (Reference here is to studies just cited.) II. The success with univariant analysis techniques are probably a function of considerable validity in the analysis of the task structure, but that individual differences are being leveled by "strong arming" them in the univariant remediation loop or branching models of sequencing. III. There will, ultimately, be a savings in the developmental/ research activities of our colleagues when our analysis procedures encompass and consequently account for differences in cognitive process and personalogical variables.

If the task we have set before us appears formidable, it is. However, we suggest that our proposal has implications for a specific domain of learning. The instructional developer need not despair so long as he can determine in which domain he is operating, and can specify the appropriate analytical tools for its analysis. The problem appears when the distinction between these domains has not been properly clarified and instructional developers proceed to use traditional analysis procedures, often with disappointing and inconsequential results.

Task Analysis, Training and Education

Task analysis has been a systematic process historically, contrived to specify training goals and conditions, and is not necessarily adequate to specify the same for other aspects of education where cognitive variables differ qualitatively. Conventionally, task analysis is employed where relevant stimuli and responses are known, the problem is defined, and tasks are structured to fit the problem. Unfortunately, many of the goals of formal education, and the associated subject matter, make isolation of stimuli and associated responses very difficult without being arbitrary. An alternative should give emphasis to analysis of content assimilation and the associated behavior of the learner, and stress the simultaneous analysis of content, learner variables, and behavior to seek interactions.

It is not the purpose of this paper to perform an in-depth review of the task analysis literature. However, it is interesting to note the lack of consensus on the definition of task analysis. Gagne (1970a) describes task analysis as a process following the specification of objectives which results in the identification of behavioral classes and their conditions for enabling learning. Miller (1962a), on the other hand, omits immediate concern for conditions and places emphasis on the behavioral requirements of task descriptions. Chenzoff and Folley (1965) give task analysis a very narrow definition and view it as the process which produces task descriptions characterized in terms of both behavioral and non-behavioral attributes.

Almost of necessity, task analysis has been built on "real-world" implementations and heuristics, growing out of the need to efficiently train men to interact with machines and/or personnel subsystems. Typically, information relevant to the formulation of valid training objectives, instructional conditions and techniques is gathered from the skilled operator or master performer working within the system being analyzed. The process has been considerably refined in recent decades by bringing the behavioral psychologist to bear on the development of reliable systems analysis. The result has been numerous attempts to codify response classes (Miller, 1962a&b; Bloom, 1956; Krathwohl, 1964) and conditions for eliciting them (Gagne, 1963,1965).

Task analysis, then, has been typically associated with training. The association has led one investigator to define very narrow parameters for training. Del Schalock (1969) views psychomotor tasks as the predominant domain of training. At another extreme, Annett and Duncan (1969) suggest the defining features of training as any instructional process generated by specific statements of objectives gained through task performance observation.

To make any fine distinction between training and education is superfluous to the goal of this paper. Certainly, there is considerable overlapping. However, it will be necessary to place these activities in relational positions along a continuum. Recalling the position stated earlier regarding the possible mismatch of task analysis and certain educational domains, along what variables can this lack of congruence be isolated? The following discussion will offer two variables, content and behavior, which can perhaps easily be accused of being overly simplistic. However, an effort has been made to achieve sufficient generality so that they may include finer discriminations of more esoteric models.

Content does not exist in a vacuum and therefore can only be considered in relation to the cognitive structure of the learner or the "master," which are quite different animals. There is no such thing as content in "pure" or nominal form because it is generated by, stored in, and retrieved from an individual's unique cognitive structure which is a function of past experience. Task analysis treats content as though it did exist in nominal form. This approach does have legitimacy if the content is not significantly affected by unique or subjective cognitive processes.

The Gagne hierarchy attempts to structure knowledge based on logical interconnections, and by this criteria achieve a hierarchy which is nominal and essentially free of personalogical differences. Instructional sequence is then based on the objectives and conditions generated by the hierarchy. But attempts to employ this strategy have raised some interesting observations. Witness the too frequent studies which failed to show any consistent superiority of logically ordered presentations over scrambled or random presentations (reviewed by Popham, 1970). The point to be gained here is perhaps the following. The nominal sequence is analagous to averaged data. It describes the general situation but not the specific or unique. The nominal sequence then holds no special isomorphism with all cognitive structures of all individual learners. Whether the presented sequence is nominal or scrambled, the individual learner must reorganize it to "fit" his own structure given his unique set, cognitive strategies and aptitudes. Although the nominal order may "fit" with little variance the structures of those who have mastered the content area, there is little or no guarantee that the naive learner can make the same accommodation <u>during</u> the learning of that content. Mediating processes unique to the learner must "transform" encoded information to be meaningful perhaps in the sense hypothesized by Berlyne (1965). Such considerations have perhaps led systems analysts Annett and Duncan to conclude that tasks "may always be analyzed into a hierarchy of categories, but that the relative position of the categories must be expected to vary (1969, p. 12)."

What is the nature of content that would lead an instructional developer to hypothesize multiple hierarchies? One means for describing the nature of content is along a continuum extending from "formal" to "thematic" (Glaser, 1966). On the basis of an earlier distinction proposed by Skinner, content lies in cognitive repertoires that are assimilated as formal or thematic. A formal repertoire is characterized by point-to-point correspondence between S's and R's. Examples include content associated with dictation, beginning reading, or operating a simple machine. In terms of Gagne's taxonomy, formal repertoires would be exhibited in behavior classes I through V. In the thematic repertoire, S's and R's are associated via intervening variables acting as mediating responses and stimuli. Melton's multi-process model of associative learning (a multivariate approach) appears immediately applicable here (1967, Cronbach & Snow, 1969). There is no formal, or one-to-one correspondence between S's and R's during learning. We cannot directly map R's on S's across learners. Examples would fall under Ausubel's meaningful verbal learning and content reflected by Gagne's classes VI and VII. Content thus lies on a continuum from "formal" to "thematic." Placement of content toward the thematic end increases the need for recognition of differentiated mediating variables and thus the complex nature of the interaction of content and cognitive structure. Therefore, to the extent that task analysis leads us toward a nominal learning structure, free of variance resulting from unique mediating variables, the more we appear to be in the tradition of training. Training becomes generally confined to content dealing with the "formal" end of the continuum.

As with content, an attempt will be made to place behavior on a continuum. At one end we can specify behavior which is essentially procedural and directly observed. Behavior follows a linear sequence of specified events and continues along a narrow path to discrete action typically having limited observable consequences (Carpenter, 1968). Examples range from tracking tasks in the psychomotor domain to adding columns of digits in the cognitive domain. At the other end of the continuum lies behavior which concerns manipulation of principles in novel situations, problem solving, or what Bruner refers to as "going beyond the information given (1957)." It is behavior having high transferability and is task-general unlike procedural behavior. The knowledge associated with the behavior must be inferred.

Given the content and behavior variables just defined, the following figure can be constructed. It is recognized that such a representation can be accused of gross over-simplification, however its intent is to provide a parsimonious and hopefully useful mneumonic for the purposes of this presentation.

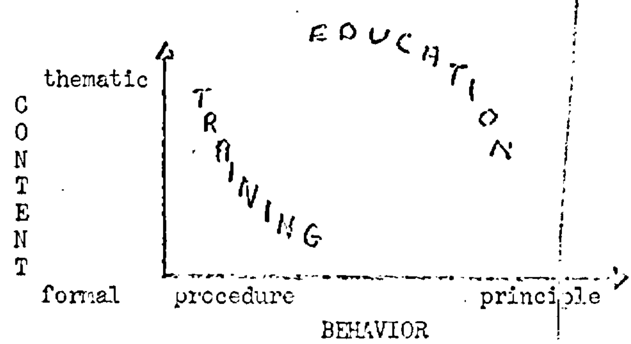


Figure 1. The Analysis Domains

It is in this "formal-procedural" domain that current task analysis techniques seem to be appropriate. As we move into the "thematic-problem solving" domain, our current analyses are likely to have less and less pay off. And it is in this area that we must begin to consider those arguments presented earlier for going beyond S-R based approaches in our development. It means moving toward analysis techniques that are truly learner-centered, as opposed to performer task-centered. Typically, task analysis is performer-centered. We observe or obtain self-reports from the performer as our main source of information concerning the tasks and their sequence. But as mentioned before in our discussion of sequencing, that performer-centered structure may not be the ideal structure for the naive learner. The performer decodes information that has been fully and meaningfully subsumed resulting in a more or less nominal structure. But it is the naive learner's position to have to encode information meaningfully, and meaningfulness is a function of that learner's history as a learner, that is his mediating process, strategies, and aptitudes. As the learner progresses toward mastery, and his ability to encode and decode approaches a way similar to that of the performer, he will begin to assume that nominal structure as the need for unique mediating variables become less useful and necessary for understanding. But _during_ learning, or more appropriately, during that phase of learning to learn in a new content area, the learner's structure is hypothesized to be something quite different than the externally represented, performer-centered, nominal structure. Isomorphism obtains over time. It is this argument that leads us to the need for what we might call learner-centered task analysis which would provide us techniques for accommodating individual differences in cognitive processing characteristics among sub-populations of learners. Required will be the merging of task and process taxonomies with special recognition of their interactions. Our task analyses in this domain would thus specify the task in its most molecular form, and those experiences which would specify either compensatory mediational processes for our learner sub-populations or experiences which would capitalize on preferred mediational processes, aptitudes or abilities.

Before continuing on to describe a specific instance of the application of our modified model of task analysis, it would be well to review, in brief form, some of the characteristics and analysis requirements of the two domains.

Table 1. Comparison of Analysis Techniques

Formal-Procedural Domain	Thematic-Principle Domain
Characteristics	
task-specific	task-general
low transfer	high transfer
nominal structure isomorphic with learner structure	nominal structure not isomorphic with learner structure
low S-R mediation	high S-R mediation
Analysis Requirements	
descriptive	descriptive and prescriptive for learner sub-population
task oriented (performer dependent-centered)	learner-dependent
S-R theory base (univariant orientation)	S-R association or information processing theory base (multivariant orientation)
nominal hierarchy and sequence	differentiated hierarchy and sequence

Formal-Procedural Domain	Thematic-Principle Domain
Analysis Requirements (Continued)	
analysis of entry behavior	analysis of cognitive process, differentiated interacting aptitudes, and entry behavior
population-general personalogical variables	sub-population specific personalogical variables
learner-general instructional treatments	sub-population specific instructional treatments

Analysis Types and Application

Now, how is such an analysis to be performed? Certainly our knowledge base for such analysis is in the Dark Ages. The study of individual differences and mediating process in verbal learning in the laboratory has certainly revived in recent years but application of what little we know from the laboratory to the developmental field is elusive.

The following procedures seem to be suggested although not necessarily in the order indicated.

Type I. Specification of an appropriate cognitive process. Cronbach and Snow have observed that Melton's multi-process model seems to offer a parsimonious explanation for most of the aptitude-treatment-interactions they have reviewed. The verbal loop hypothesis (Glanzer, 1967) has been used with some success by Salomon. Also, Salomon (1971) has recently suggested five additional process models. Empirical verification is a difficult undertaking. Careful analysis of the hypothesized mediators and observation of the intra-task behavioral correlates seems to offer most promise. Careful control in the specification and validation of treatments could result in confirmation of the network of hypothesized mediators. McGuire (1961) has suggested some creative approaches to this problem. It should be noted that anecdotal observation of individual learners and introspection are useful tools to be considered as well.

Type II. Task structure analysis. Given the previous analysis, it is possible that the more conventional task structure analysis would be appropriate. The familiar technique of starting with criterion behavior and asking the question, "What does the learner need to know to . . . .?" This logical analysis should be complimented with the newer scaling techniques (Resnick, 1969) for examining the efficacy of the task structure. As noted previously, it is conceivable that two or more task structures could be hypothesized for different sub-populations of learners. It is assumed that the appropriateness of the sequence would be learned in validation.

Type III. Analysis of the contribution of aptitude measures on task performance. The use of memory or rote factors should be included in nearly all analysis. Recent research by Stake (1961), Allison (1960), and Duncanson (1964), etc., have demonstrated independent memory factors contributing to performance across a wide variety of tasks (suggesting more serious attention to mneumonics and other "memory aids" in complex tasks). In addition, other aptitude measures should be selected in terms of the relevance to the Type I analysis. Multivariant empirical analysis could proceed in conjunction with both Type I and Type II analyses. The aptitude measures could be factors analyzed in conjunction with the variation of behavior across the learning structure in Type II analysis or across the learning performance data in Type I analysis. The multivariant analysis can be modeled after the research of Stake (1961) and Allison (1960) and Duncanson (1964). Intra- and post-task learning performance data, memory and other personalogical variables could be, simultaneously, examined across the specific tasks to be analyzed. Fleishman's (1966) work in the psychomotor domain could offer some promise for cognitive learning. The generic questions to be asked would include:

1. What aptitudes contribute to the terminal learning performance and efficiency?
2. What aptitudes contribute to intra-task performance?
3. How do learning and aptitude measures cluster?

The results of these analyses would suggest which aptitudes are univariantly and differentially relevant at various points in the task structure. This information could, also, be used in relation to Type I analysis. The differential relationship of aptitudes across different treatments would tend to prove or disprove the hypothesized relationships between and among mediators. Strategies will more directly follow from the analysis (Salomon, 1970).

These three types of analyses will, of course, be difficult to apply in a large number of developmental situations. However, the intent of this paper is to recommend an enlarged view of the analysis procedure and thus encourage appropriate research and the imaginative developer.

A recent study by Schwen (1969) demonstrates some of the procedures recommended above. The study was built on the work of Merrill (1965,1967). Merrill has utilized an artificial science to examine the efficiency of various types of sequencing strategies.

Through a series of well controlled studies, he manipulated several sequence variables (developed from a complex hierarchical learning task).

Presentation frames (P-frames) carry the primary information load and were keyed to the task structure. In the event of an error, a Specific

Review frame (SR-frame) provided a problem review directly related to the specific problem missed. A General Review frame (GR-frame) provided the relevant principle for examination.

In an overly simplified manner, Merrill's work can be summarized by the generalization: In a hierarchical learning task, specific review is superior to general review particularly in respect to time to criterion measures.

It should be noted that the Type II task analysis procedure used by Merrill is a highly advanced and sophisticated example of analysis in the univariant case.

Schwen observed that, over a series of studies, a control groups' achievement scores were the same as the experimental groups'. The control group treatment involved the use of presenting the summary principles of the science to the learner for pre-study and then branching the student through a criterion test with specific review

In summary, the two treatments can be compared in the following manner:

<u>Experimental Group</u>	<u>Control Group</u>
Instructions	Instructions
Nothing Comparable	Summary Principles
P-Frame S-R Frame Sequence	Nothing Comparable
Criterion Test - Integrated With Above -- No Review in Test	Criterion Test With Specific Review
Retention Test	Retention Test

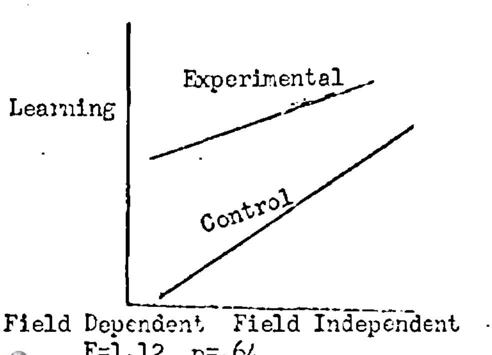
Cronbach and Snow (1969) have observed that NSD's or equal means on learning measures might very well suggest a disordinal interaction between treatments and some personalogical variables, particularly when the treatments appear to be affecting different cognitive mediators.

In this case Schwen hypothesized a cognitive preference model where field independent learners would perform better in the control group treatment. Field independent learners are quite analytic and spatially oriented. They seem to be able to operate with a minimum of contextual information and still achieve. Also, the construct is related to more flexible personality styles and it is not related to vocabulary or mathematic portions of IQ tests.

On the other hand, field dependent learners are less analytic, more dependent on the stimulus situation for organizing context and they tend to be less flexible.. The rich, highly organized and structured experimental treatment seemed to be suited to this group of learners. It is useful to note that neither of the learner groups is considered better or worse (smarter-dumber, etc.).

Post-test data was the primary dependent variable in the Schwen study. However, intra-task data was collected and is being analyzed at this time. In this particular case, the intra-task data of interest is the error rate and time to sub-criterion measures related to aptitude constructs. For example, a higher error rate and more time to criterion is expected from field dependent subjects in the control group. The opposite is predicted for field independent subjects in the experimental group.

The data from the Schwen study can be summarized in the following manner:



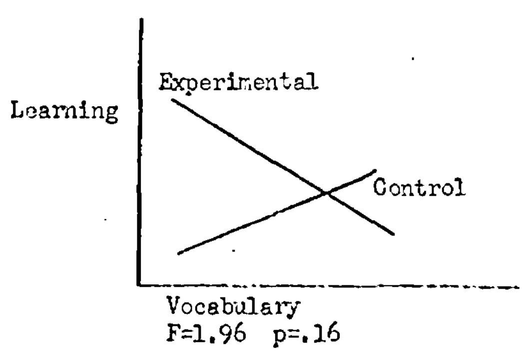


Figure 2. Summary of Schwen Data

Obviously, the original hypothesis was not confirmed. The relationship between the aptitude and learning was significant for the control group alone.

The post hoc analysis, using a vocabulary measure, produced data that may be of use in future experimentation.

If the relationship can be enhanced producing a significant disordinal interaction, it would seem that a compensatory model would be suggested. Under these circumstances the experimental group would seem to be providing appropriate practice in stimulus differentiation (Melton, 1967) for those low in vocabulary aptitude. The control group would be providing the minimal amount of instruction needed for those high on the vocabulary aptitude.

This example does not demonstrate the wide variety analyses that are possible or desirable. However, the major classes of analyses are represented. Type I analysis can be observed in Schwen's hypothesizing about the cognitive processes. More advanced analyses could have been performed by correlating the selected aptitude measures with the observable mediator related behaviors within the task.

Type II analysis was primarily performed by Merrill. It should be noted, however, that an examination of the task structure has not been reported in the literature. The strength of the Merrill studies lies in the validation of the sequence.

One aspect of Type III analysis is represented in the regression analysis in the Schwen study. More sophisticated forms of analysis have been referenced above.

In summary, the authors have argued for an enlarged view of the analysis procedure, moving from the procedures which assume learning to be a univariant phenomena to more complex procedures based on the assumption that learning is a multivariant phenomena. The analysis procedures are recommended in the thematic-principle domain and requires multivariant analysis of the cognitive processes, related mediators and appropriate aptitudes.

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